THE IMPACT OF AN ENVIRONMENTAL TAX ON ELECTRICITY GENERATION IN SOUTH AFRICA

R Seymore*, P D Adams, M Mabugu, J H van Heerden and J Blignaut

Abstract

In the 2008 budget of the Minister of Finance, the South African Government proposed to impose a 2 cents/kilowatt-hour (c/kWh) tax on the sale of electricity generated from non-renewable sources; this tax is to be collected at source by the producers/generators of electricity. The intention of this measure is to serve a dual purpose of protecting the environment and helping to manage the current electricity supply shortages by reducing demand. The objective here is to evaluate the impact of such an electricity generation tax on the South African, SACU and SADC economies.

The paper firstly considers the theoretical foundations of an electricity generation tax supported by international experiences in this regard. This section also contrasts the suitability of a permit with a tax system to achieve CO_2 emission reduction.

We subsequently apply the Global Trade Analysis Project (GTAP) model to evaluate the impact of an electricity generation tax on the South African, SACU and SADC economies. We simulate the proposed tax as a 10 percent increase in the output price of electricity. We assume a closure rule that allows unskilled labour to migrate and a limited skilled workforce. As expected, the electricity generation tax will reduce demand. Due to the decrease in domestic demand, export volume increases and import volume decreases, this is despite a weaker terms of trade. We also found that unemployment for unskilled labour increases and wages of skilled workers are expected to decrease. A unilateral electricity generation tax will benefit other SACU and SADC countries through an improvement in relative competitiveness, as shown by the improvement of the terms of trade for these regions. If, however, the benefits of pollution abatement are internalised, then electricity generation tax is expected to yield a positive effect on the South African economy.

[*] Department of Economics, University of Pretoria and second author from Centre of Policy Studies, Monash University. The authors would like to thank an anonymous referee of Economic Research South Africa (ERSA) for the comments and suggestions. The author acknowledges financial support from ERSA.
Email: reyno.seymore@up.ac.za

1. Introduction

The South African government has proposed the imposition of a 2 cents/kilowatt-hour (c/kWh) tax on the sale of electricity generated from non-renewable sources. This tax is to be collected at source by the producers/generators of electricity. The intention of this intervention is to reduce South Africa's carbon dioxide emission load and to help manage the current electricity supply shortages by reducing demand (Republic of South Africa, 2008).

The world produced approximately 49,000 million ton (Mt) CO_2-equivalent in 2004, mainly from deforestation and energy generation. South Africa's share is about 1% of the global figure, or 440Mt. The emissions per capita in South Africa are very high, i.e. 9,5tCO_2-eq., compared to averages of 5,0tCO_2-eq. for developing countries and 6,8tCO_2-eq. for the world. Emissions per capita of Brazil are 13.1t CO_2-eq., China 3,9t CO_2-eq. and India 1.8t CO_2-eq. per person. African and developing countries emit less CO_2 for a unit of GDP than the world average, but South Africa is the exception and emits more than OECD countries. South Africa's emissions per GDP, or its emission intensity, is 0,75kg/$, whereas the world average is 0,56kg/$ (Winkler, 2007).

Eskom dominates the electricity industry in South Africa and generates approximately 95 percent of electricity in South Africa (Eskom Holdings Limited, 2009). As shown in Table 1, coal-fired power stations contribute approximately 89 percent of electricity generation capacity in South Africa. Eskom owns 96 percent of all generation capacity in South Africa and 100 percent of the national transmission grid. 60 percent of electricity is distributed directly to end-use customers and the remaining 40 percent is distributed through municipal distributors (Republic of South Africa, 2007). However, the electricity distribution industry is currently in a process of restructuring. In March 1997 the South African Cabinet approved consolidation of the electricity distribution industry into six Regional Electricity Distributors (REDs). Since then, the establishment of REDs has been met with limited success. On 25 October 2005, in an attempt to address the challenges that the distribution sector faces, Cabinet approved the creation of six "wall-to-wall" REDs. These REDs should be created as public entities and the Department of Minerals and Energy, through Energy Distribution Industry (EDI) Holdings, should oversee and control their establishment (Republic of South Africa, 2007).

Table 1: South Africa's electricity capacity – 2004

Energy source	Capacity (mw)	Percent of total
Coal	38 209	88,8
Nuclear	1 800	4,2
Bagasse	105	0,2
Hydro	668	1,6
Gas turbines	660	1,5
Pumped storage	1 580	3,7
Total	43 022	100

Source: Republic of South Africa (2006)

The South African electricity usage is characterised by a few energy intensive industries as shown in Table 2. The Mining and Extraction industry consumes more than 50 percent of electricity, but contributes only 3 percent to domestic production at market prices and 14,58 percent to exports at market prices. Similarly, the "Electricity" and "Utility and construction" industries consume 25 percent of electricity, but only contribute 6,17 percent to domestic production and 0,58 percent to exports at market prices.

Table 2: Electricity consumption by industry

	Percentage of electricity used in production	**Percentage of domestic production at market prices**	**Percentage of exports at market prices**
Electricity	14,06	1,53	0,45
Grains and crops	0,00	1,59	4,13
Livestock and meat products	0,04	2,15	0,65
Mining and extraction	50,89	3,05	14,58
Processed food	0,05	5,21	4,77
Textiles and clothing	0,20	2,22	1,90
Light Manufacturing	1,95	11,15	16,38
Heavy Manufacturing	8,37	18,46	44,12
Utilities and construction	10,96	4,64	0,13
Transport and communication	3,57	17,99	6,75
Other services	9,90	32,01	6,12
Total	100,00	100,00	100,00

Source: GTAP database, Preliminary version 7

South Africa is a member of the Southern African Power Pool (SAPP) which facilitates electricity distribution within SADC. As shown in Table 3, South Africa recorded a trade surplus in electricity from 2003 to 2008 of between 3 000 GWh and 4 500 GWh.

Table 3: South African international trade in electricity

	Imports GWh	**Exports GWh**	**Net exports**
2000	4719	4007	-712
2001	7247	6519	-728
2002	7873	6950	-923
2003	6739	10136	3397
2004	8026	12453	4427
2005	9199	12884	3685
2006	9782	13766	3984
2007	11348	14496	3148
2008[1]	9492	12968	3476

Source: Republic of South Africa (2009)

[1] The data for 2008 is only for the first 11 months.

The primary objective of this paper is to evaluate the impact of an electricity generation tax on the South African, SACU and SADC economies. The next section considers the theoretical foundations of an electricity generation tax and examines some evidence put forth by similar studies. In the third section, the Global Trade Analysis Project (GTAP) model and data are discussed. This is followed by an analysis of the results. The last section contains the conclusion, as well as the limitations of the model.

2. Literature review[2]

2.1 Introduction

In this section we refer to results obtained from simulating taxes on electricity by making use of national models of South Africa. We start by summarising the conventional wisdom on economic instruments for curbing pollution, and then motivate the choice of taxing electricity in South Africa for this purpose.

2.2 Permits or taxes?

Economic measures use the price mechanism to internalise the negative externalities associated with fossil fuel use. These measures could be used, at least cost to the economy, to achieve environmental targets. If marginal abatement costs could be equalised across all agents, action will be taken at the points in production that will result in the most efficient and cheapest abatement (UP, 2007). UP (2007) identified tradable emissions schemes and taxes on emissions (or proxies of emissions) as the two most important economic measures in the context of emissions reductions.

Taxes on emissions, also called Pigouvian taxes, require that the total value of damage caused by an extra unit of emissions is equal to the tax levied per unit of emissions (Norregaard & Reppelin-Hill, 2000). The result of this tax is to signal the true social cost of pollution to the emitter, who then has the financial incentive to reduce emissions to the point where the financial implication of one unit reduction to the emitter, is equal to the social damage involved.

On the other hand, in a system of marketable permits, permits are allocated by the regulatory authority that is equal to the aggregate quantity of emissions. This allocation could, for example, be through an auction (Norregaard and Reppelin-Hill, 2000). In line with the Coase theorem, Perkins *et al.* (2006) argued that the creation of a marketable permit system can achieve an efficient outcome with minimal government intervention. Although these permits may be the most-efficient way to reduce pollution, the requirements to function optimally are stringent and not often met in practice.

[2]This part of the paper is commissioned research for The National Treasury (South Africa) and funded by AUSAid. The authors would like to thank ASSET Research and CoPS for facilitating the project.

According to McKibben and Wilcoxen (2002), especially under uncertainty, taxes on emissions tend to be more efficient than a permit system. Furthermore, Rosen (1999) remarks that the relevant issue is not whether the perfect method of dealing with externalities is taxing emissions, but rather, whether or not they are likely to be better than other alternatives.

2.3 The tax base

Van Heerden *et al.* (2006) used a national CGE model of South Africa (UPGEM) to simulate various environmental taxes, and found three main effects on an economy:

- An environmental tax addresses the negative externalities caused by electricity generation, this leads to changes in the economy through an increase in production costs. This will also lead to an increase in the relative prices of electricity intensive products. The higher production costs of these products will decrease export demand and increase import demand. As a result, output in trade related services, especially energy intensive products, would decrease. Therefore, labour will be reallocated from these sectors to non-traded sectors.

- It will increase government revenue, but if this revenue is not recycled, purchasing power and household consumption will decrease.

- The change in the economy created by the tax will induce a change in consumer behaviour, for example, substitution away from energy and energy-rich sectors. This could lead, in the long run, to more efficient technologies.

All three effects contribute to the reduction in energy demand and therefore to a reduction of carbon emissions in the taxing country (Van Heerden *et al*., 2006).

The use of fossil fuels in production can be taxed at different stages of production. As shown in Table 4, environmental taxes and charges can take different forms. Taxes can be raised on the outputs themselves at the consumption stage; the production of fossil fuels; their use as inputs; or governments can choose to tax the actual emissions of greenhouse gasses.

The choice of where to tax fossil fuel use has several effects. Firstly, there is an effect on the emission reduction incentives. Generally, the closer the tax incidence is to the source of emissions, the more effective the tax. Secondly, taxing end-consumption has a smaller effect on the competitiveness of the country, than taxing production (UP, 2007). Thirdly, regardless of the the placement of the statutory tax incidence, the economic incidence affects the distribution of income in the economy. Lastly, the administration costs and feasibility of the tax are determined by the point in the production where the tax is levied (UP, 2007).

Environmental taxes and charges can be classified in a number of ways. An environmental tax is defined by the OECD as “tax whose tax base is a physical unit (or proxy of it) that has proven specific negative impact on the environment”.

The National Treasury noted that classification of environmental taxes according to the tax base and not the intent of the tax is important for the following reasons:

- It is in line with international practices and facilitates cross-country comparisons;
- Unintended environmental outcomes are captured; and
- It provides a consistent framework to evaluate the impact of a particular tax instrument over time irrespective of the original intent.

Table 4: Environmental taxes and charges

Tax	A tax is a compulsory unrequited payment not proportional to the good or service received in return for that payment. Important characteristics of a tax include: beneficiaries constitute distinct groups of agents; no direct benefits accrue to individuals in exchange for payments; payments are enforced in terms of legislation; and government or organs of the state direct the use of tax revenues.
User Charge	A user charge is a requited payment for a specific service rendered. These payments are based on the individual benefit principle and attempt to link the amount paid to the benefit received by a specific individual. Important characteristics of a user charge include: a marketable service is provided to individual beneficiaries; direct benefits accrue to beneficiaries in exchange for payments; and transactions take place in a willing buyer willing seller market. As a guiding rule, user charges should not exceed the average cost of providing the service. In some instances, user charges might be set below average cost to ensure affordability.
Levy	A statutory levy is a compulsory payment and is, therefore, a tax.
Earmarked Tax	An earmarked tax is a tax, the revenues from which are used to finance a specific activity or programme.

Source: Republic of South Africa, 2006

However, the goal of environmental taxation is to reduce emissions through redirecting behaviour away from actions that are detrimental to the economy. According to conventional tax wisdom, environmental taxation will be most effective in influencing behaviour, if the activity causing the pollution is taxed directly (OECD, 2001). Therefore, where there is a clear environmental objective, the tax should be targeted as directly as possible. The preferred situation is a direct link between the tax and the environmental issue. If this is the case, incentives to change behaviour are likely to be stronger and unintended effects will be minimised (Republic of South Africa, 2006). The implication for CO_2 emissions is to tax the actual emissions directly. Unfortunately, this is usually not a feasible option due to the high administration cost associated with such a tax. As a result, no country has ever imposed a direct tax on actual emissions (UP, 2007). The closest proxy for actual emissions taxes is an input tax on fossil fuels that discriminates based on the carbon content of different fuels used in the production process (UP, 2007).

It should be noted that the direct effects of energy taxes are usually found to be regressive, due to the relatively high proportion of income spent on energy by poorer households. However, these regressive effects tend to be smaller when indirect effects, such as the increase in the relative prices of electricity intensive products, are taken into consideration (UP, 2007).

2.4 Electricity generation tax: Some evidence

In 2008 the South African government announced the intention to levy a tax on electricity generation in South Africa. As discussed in the introduction, the aim of this tax is to reduce the country's emission intensity through providing an incentive to producers to switch away from processes associated with high levels of emissions. Since this tax will create a change in the economy, the economic welfare losses of rising energy prices have to be compared to the social welfare gains of reduced emissions.

The Scenario Building Team (SBT) at the Department of Environmental Affairs and Tourism in South Africa (Republic of South Africa, 2007) showed that any level of taxation induces switching away from coal-fired electricity plants and coal-based technologies. Despite the costs associated with the switching, increased tax levels provide the incentive for switching away from coal-based processes, and this is a desirable outcome from an environmental perspective, as well as being the principle objective of the environmental tax. It is also reported that at levels beyond 208,3 cents per kWh the net economic impact will be negative. Results from the computable general equilibrium model used by the SBT (Republic of South Africa, 2007), showed at high levels of taxation overall production and employment levels are likely to decline. GDP may decrease by between 2 and 7 per cent for a tax of 208,3 cent per kWh, and decrease by between 9 and 17 per cent for a tax of 625 cent per kWh.

As noted earlier, tradable emissions schemes and taxes on emissions (or proxies of emissions) are the two most important economic instruments in the context of emissions reductions. Due to the monopolistic character of the energy industry in South Africa (see Section 1), a tradable permit system would in effect become a command-and-control system. This would be the same as a direct quota to Eskom and does not seem to make much sense (UP, 2007).

However, the impact of an environmental tax on incentives to abate emissions cannot be analysed in isolation. The market structure and price elasticities of demand are both vital in determining who bears the brunt of the tax incidence and how behaviour will change as a result of the tax.

Given the monopolistic nature of the South African electricity generation industry, passing through the increased prices of fossil fuel to consumers should be relatively easy. This will serve to limit the incentives to shift to lower-carbon fuels and as a result, the output-demand effect could be more important than the input-substitution effect (UP, 2007).

The price elasticities of electricity demand, as well as government price setting regulations, will also influence the extent to which the tax burden can be shifted to end-consumers. Blignaut and De Wet (2001) calculated the arc price elasticity of electricity demand to investigate the effect of a change in the price of electricity on the consumption of energy over a twenty-year time period in South Africa. They reported that the manufacturing sector is relatively price inelastic in its decision making process. As a result, the price of electricity is a weak instrument to bring about behavioural changes in the manufacturing sector of South Africa. Furthermore, since electricity exhibits the characteristics of a consumable, essential as well as non-luxury commodity, it can be expected that the demand for electricity will reflect the same inelastic price elasticity globally.

An electricity generation tax can be effective in the reduction of emissions, despite the inelasticity of electricity, the monopolistic nature of the market and price regulation. Van Heerden *et al*. (2006) showed the almost one-to-one relationship between coal combustion and electricity. An electricity tax will increase the price of electricity. This increase will bring about a relatively small change in consumption. However, this reduction in consumption will reduce emissions almost on a one-to-one basis (Van Heerden *et al*., 2006).

Van Heerden, Blignaut and Jordaan (2008) modelled a 10 percent tax increase on the price of electricity to determine the effect of such an increase on the consumer price index. The model used in their study, UPGEM, was developed as a computable general equilibrium model of the Department of Economics at the University of Pretoria. The model database was based on the official 1998 Social Accounting Matrix of South Africa, which divided households into 48 groups and distinguished 27 sectors. Also, the model's closure rules reflected a short-run time horizon. They found the direct impacts of an increase in electricity prices were mostly negative on the economy as industry production as well as GDP decreased.

The model presented in this paper simulates an equivalent increase in electricity prices, but goes a step further by looking not only at the South African economy, but also the impact on other SACU and SADC countries. Furthermore, the model gives a detailed breakdown on industry level and distinguishes between skilled labour and unskilled labour. This should enable policy makers to fully assess the impact of the proposed electricity generation tax, not only on a national and international level, but also on an industry level.

Kerkela (2004) also used the GTAP model to simulate electricity price increases in Russia, where consumers are subsidized for the consumption of electricity. Our results compare very well with hers, but we point out below that the results are not exactly the same as those of the national models mentioned above.

2.5 Double dividend: Fact or fiction?

If the revenue generated from the environmental tax is recycled in a manner that addresses the current distortions in the economy, a second dividend becomes possible. UP (2007) defined the first dividend as the improvement in the environment due to the pollution abatement effect and the second dividend as possible improvement in the efficiency of the economy. This second dividend could be achieved, and the economy could move closer to the optimal situation if the revenues are used to reduce existing distortions caused by taxes on labour and capital.

The potential of a second dividend depends on the initial state of the tax system. Where there are initial taxes, environmental taxes distort choices concerning labour supply and demand as well as investment. According to UP (2007), this tax interaction effect may dominate the positive effects of reducing other taxes. In other words, a double dividend is not automatic, but depends on the initial tax system and the initial distortions created. According to Van Heerden *et al*. (2006) a reduction of the energy demand through increased energy taxes will not lead to a reduction of tax revenues in South Africa due to the virtual absence of initial energy taxes. Thus, the loss of public funds is limited if there is a shift in taxes towards energy, which makes a double dividend more probable.

3. Model and data

3.1 Introduction

This paper applies the Global Trade Analysis Project (GTAP) model, which is coordinated by the Centre for Global Trade Analysis at Purdue University. The GTAP model is the pre-eminent modelling framework for the analysis of trade and environmental issues across countries (www.gtap.agecon.purdue.edu). Nearly all analyses of Free Trade Agreements by governments and individual academics have utilised aspects of the GTAP model and/or database.

3.2 The GTAP model

GTAP is a multi-region CGE model designed for comparative-static analysis of trade policy issues. All GTAP datasets are defined in terms of three primary sets: the set of countries and regions, the set of sectors and produced commodities, and the set of primary factors (Rutherford and Paltsev, 2000). The aggregation of the model used in this paper distinguishes four regions, namely South Africa, SACU countries excluding South Africa, SADC countries excluding SACU and the Rest of the World. The 57 GTAP sectors have been aggregated into 11 sectors shown in Table A1 in the Appendix. In addition to the 11 sectors, there are three other agents in each region: a capital creator, a representative household and the government.

The GTAP model features explicit modelling of international transport margins, a global bank designed to mediate between world savings and investment, and a consumer demand system designed to capture differential price and income responsiveness across countries (Hertel and Will, 1999). Macroeconomic data is used in GTAP to update the regional input-output tables to a common base year - 2004 for the GTAP 7 database used in this paper. All the coefficients in the regional input-output models, initially in national currency units, are scaled-up to external GDP data in 2004 US dollars. Thereafter, private consumption, gross capital formation and government consumption are used to update the values of these aggregates in the regional input-output tables (Hertel, 1997).

The GTAP model optimises the behaviour of agents in competitive markets to determine regional supply and demand of goods and services. Optimising the behaviour also determines sector demands for primary factors, i.e. labour, land, capital and natural resources. In each region there are two types of labour (skilled and unskilled) and a single, homogenous capital good. In standard comparative static applications of the model total supplies of all endowment factors (capital, labour, land and natural resources) are fixed for each region (in other words; South Africa, SACU excluding South Africa, SADC excluding SACU, and the rest of the world). For the applications reported here, we adopt a different convention, with skilled labour fixed for each region, but unskilled labour allowed to move across regions to eliminate any initial disturbances to real wage rates. This provides a more accurate description of the South African economy, which is characterised by high structural unemployment in the unskilled labour market and a limited supply of skilled labour in the skilled labour market.

Other key assumptions are:

- Public and private consumption expenditures as well as nominal savings in each region are assumed to move with regional income. National investment is modelled as being responsive to changes in rates of return on capital. Global investment is assumed to be fixed. Therefore a region which benefits more from an exogenous shock will, at the expense of other regions, increase its share of global investment.

- We assume that the exogenously imposed shocks in each scenario have no effect on rates of commodity taxes, other than those used to impose the shocks.

- Here we assume that all technology variables are unchanged. For example, an increase in the price of electricity has no impact on the technology used in the production of electricity-intensive industries such as mining.

- Capital stocks are fixed, while rates of return are allowed to vary to accommodate the unchanged capital.

The GTAP model is a multi-country model focussing on the interaction among countries arising from the flows of goods and services. Its representation of savings and investment linkages is relatively weak, and so it does not pick up the possible inter-country shifts in assets (financial and physical) that may arise from the imposition of an electricity generation tax. Furthermore, the entire final demand system is treated as the demand system of a representative household. It is therefore not possible to analyse the welfare effects of the tax on different households as there is effectively only one household in the model.

The model does not endogenously predict the emergence of new industries, such as coal generation with carbon capture and storage or nuclear. New industries must be exogenously introduced, with the size and timing of the new industries specified by the model user. In the modelling conducted for this study it is assumed that no new industries emerge as a result of an electricity generation tax. However, this is a realistic assumption in South Africa in the short run. As discussed in the introduction, Eskom is investing in expanding the electricity generation capacity in the long run.

The version of GTAP used in this paper is static, not dynamic. Accordingly, there is no allowance for the inter-temporal linkages between investment and capital, and between savings and consumption. While the model is able to project the likely changes in capital by industry and region associated with an electricity tax, there are no endogenous mechanisms that allow it to project the time-pattern of investment changes that bring about the projected changes in capital. A comparative-static framework also prevents a proper analysis of the adjustment costs (short-term and long-term) associated with an electricity tax.

For the simulations discussed in this paper, no attempt was made to include the possible effects of climate change in the base case. That is, there are no assumptions made about the possible costs under 'business as usual', as a result of climate change. Neither do we include other more serious predictions of climate scientists, such as the flooding of low-lying urban areas or increased forest fire activity. Not allowing for the possible effects of climate change means that we do not account for any of the possible direct economic benefits arising from abatement achieved by an electricity tax. Also note that limited welfare analysis is possible, as there is only one household defined in the model.

3.3 The GTAP database

The GTAP database comprises of input/output data for each region; bilateral trade data derived from United Nations trade statistics; and support and protection data derived from a number of sources. The simulations reported in this study are based on a preliminary release of Version 7 of the database. Documentation for the Version 6 data set is given in Dimaranan (2006). The Version 7 database contains estimates of production costs, final demand values, bilateral trade values and various tax levels for 2005.

3.4 Simulation design

The version described in the previous section is used to simulate a 2c/kWh tax on electricity generation. It should be noted that changes in trade volumes are those linked to a 2c/kWh increase in the tariff, which is equivalent to a sector-wide weighted average of 10% (Blignaut, Chitiga-Mabugu and Mabugu, 2005).

The shocks were imposed via changes to output taxes in the production of electricity. An output tax drives a wedge between the price received by producers and the price paid in the market. Thus, a simulation of a 10 percent increase in the output tax of electricity was imposed.

4. Results

The effect of a unilateral 2c/kWh electricity generation tax in South Africa is shown in Table 5 Note that revenue neutrality was also simulated and the results reflected no statistically significant differences from the results reported below.

All the macroeconomic variables reported in Table 5 (with the exception of the real export volume), decrease for South Africa when simulating a unilateral implementation of an electricity generation tax. This tax drives a wedge between the price received by producers and the price paid in the market. As discussed in Section 2, due to the inelastic nature of the demand for electricity, the price of electricity can be expected to increase by around ten percent. Since electricity is an input in most production processes, an increase in the electricity tariff will lead to an increase in production cost and thus suppress economic activity. This explains the 0,28 percent contraction of the real South African GDP. As the real GDP contracts, national income will decrease with a resulting decrease in real private consumption, real public consumption and real investment.

Table 5: Effects of an electricity generation tax in South Africa (Percentage deviations from no-tax case)

	South Africa	Sacuexcsa[3]	Sadcexcsa	Row
Real GDP	-0,28	0,01	0,01	0,00
Real private consumption	-0,40	0,06	0,02	0,00
Real public consumption	-0,17	0,03	0,01	0,00
Real investment	-2,29	0,12	0,07	0,01
Real import volume	-0,69	0,13	0,04	0,00
Real export volume	0,70	0,02	0,00	-0,01
Terms of trade	-0,15	0,60	0,02	0,00
Unskilled employment	-0,77	0,07	0,01	0,00
Skilled employment wage	-0,63	0,07	0,04	0,00
Industry production				
Electricity	-4,29	1,47	0,45	0,02
Grains and crops	0,31	-0,07	-0,02	0,00
Livestock and meat products	-0,08	-0,05	0,00	0,00
Mining and extraction	-0,35	0,00	0,00	0,00
Processed food	0,01	-0,06	-0,02	0,00
Textiles and clothing	0,34	0,15	-0,02	0,00
Light manufacturing	0,12	-0,29	-0,14	0,00
Heavy manufacturing	-0,18	0,01	-0,09	0,00
Utilities and construction	-1,84	0,10	0,06	0,01
Transport and communication	0,01	0,00	0,00	0,00
Other services	-0,19	0,04	0,01	0,00

[3]Where SACUEXCSA is SACU countries excluding South Africa, SADCEXCSA is SADC countries excluding SACU countries and ROW is the rest of the world.

Table 5 shows that despite higher production costs as a result of more expensive electricity, the terms of trade weaken for South Africa. This is because the domestic demand decrease outweighs the decrease in domestic production, thereby reducing the domestic price level. Therefore, contrary to the expected outcome, despite the higher production costs real export volumes increase by 0,7 percent and the real import volume decreases by 0,69 percent. The effect of the decrease in domestic household and government demand can be seen in Table 6. Domestic prices will decrease in all the sectors. This is similar to a leftward shift of the demand curve in a static partial equilibrium analysis.

Table 6: Demand and market price percentage changes: South Africa

	Household demand	Government demand	Market price
Electricity	-3,37	-9,24	10,00
Grains and crops	-0,29	-0,51	-0,26
Livestock and meat products	-0,32	-0,51	-0,32
Mining and extraction	-0,50	-0,71	-0,03
Processed food	-0,30	-0,37	-0,41
Textiles and clothing	-0,35	-0,45	-0,34
Light manufacturing	-0,43	-0,59	-0,27
Heavy manufacturing	-0,49	-0,70	-0,06
Utilities and construction	-0,36	-0,49	-0,28
Transport and communication	-0,38	-0,33	-0,42
Other services	-0,37	-0,17	-0,57

The reduction in production will also translate into job losses, with unskilled employment shedding 0,77 percent. For skilled employment, wages will decrease by -0,63 percent, also due to the decline in real GDP. This is a major contributing factor towards the economy-wide decrease in demand by households and the government.

A more detailed picture arises from a breakdown by industry production. Despite lower domestic prices, three sectors will benefit from the electricity generation tax, namely: ‘Grains and crops’; ‘Textile and clothing’; as well as ‘Light manufacturing’. These results are in line with expectations as these industries are non-energy intensive industries (see Table 2) and should benefit from the movement of factors of production away from energy intensive sectors. They also benefit from reduced input prices since domestic prices have fallen.

The “Processed food” as well as “Transport and communication” industries will experience an insignificant impact on domestic production. The other industries are all set to cut production, with the “Electricity” industry at -4,29 percent and the “Utility and construction” industry at -1,84 percent being hit hardest. The “Mining and extraction”, “Heavy manufacturing” and “Other services” industries also record relatively high negative growth, as they use relatively more electricity than other sectors.

SACU countries, excluding South Africa will benefit from the unilateral electricity generation tax. South Africa is the dominant economic power in the region and the tax will improve the relative competitiveness of the other SACU countries, specifically in the production of electricity. However, it can be expected that these increases in the production of electricity will mainly be through coal-fired power stations, implying possible carbon leakage. As shown in Table 7, South Africa will reduce electricity production by 4,29 percent and increase electricity imports by 26,53 percent, while SACU excluding South Africa will increase domestic production by 1,47 percent and increase electricity exports by 1,44 percent. SADC excluding SACU is set to increase domestic production of electricity by 0,45 percent and increase exports by 0,58 percent. The impact on the rest of the world as a macro region will be insignificant as shown in the last column in Table 5, in line with the fact that South Africa is considered a small country in global trade.

Table 7: Electricity flows (percentage changes)

	SOUTH AFRICA	SACUEXCSA	SADCEXCSA
Production	-4,29	1,47	0,45
Exports	-35,01	1,44	2,09
Imports	26,53	-1,55	-0,58

From Tables 5-7 we conclude that the economic incidence of higher electricity prices in South Africa falls on the domestic consumers, who lose their jobs and who have to pay more for electricity. Our competitors in SACU and SADC would be the main beneficiaries of this suggested policy implementation.

The CO_2 abatement has been calculated, using the greenhouse gas emissions inventory as developed by Blignaut, Chitiga-Mabugu and Mabugu (2005). Economic benefits accruing to CO_2 abatement was calculated at R100 per ton, based on a low estimate of approximately Euro8 for a Certifiable Emission Reduction certificate. As reflected in Table 8, the reduction in CO_2 emissions in the electricity sector will be worth R949 million, and pollution abatement across the economy will yield a benefit of R970 million.

A sensitivity analysis has been conducted on the price elasticity of demand for electricity in the South African economy (0,47) and the elasticity has been found to be robust at a 10 percent variation using the Stroud quadrature and solving the model 22 times.

5. Conclusion

The South African government has proposed the imposition of a 2c/kWh tax on the sale of electricity generated from non-renewable sources; this tax is to be collected at source by the producers/generators of electricity. The intention of this measure is to serve a dual purpose of protecting the environment and helping to manage the current electricity supply shortages (Republic of South Africa, 2008).

Table 8: CO_2 abatement benefit: South Africa

	Change in CO_2 emissions (Mt)	Benefit (R million's)	Change in industry output (R million's)
Electricity	-9,487	948,68	-309,61
Grains and crops	0,024	-2,44	23,19
Livestock and meat products	-0,001	0,14	-8,58
Mining and extraction	-0,028	2,75	-50,9
Processed food	0,000	0,00	2,66
Textiles and clothing	0,000	0,00	35,3
Light manufacturing	0,019	-1,94	60,78
Heavy manufacturing	-0,184	18,41	-153,03
Utilities and construction	-0,048	4,82	-403,78
Transport and communication	0,005	-0,45	4,9
Other services	-0,005	0,50	-293,33

The primary objective of this paper was to evaluate the impact of such an electricity generation tax on the South African economy. The paper firstly considered the theoretical foundations of an electricity generation tax and examined some evidence put forth by similar studies. It became evident that in the case of South Africa, due to the structure of the market, an electricity generation tax is preferred to a permit system. Despite the inelastic demand for electricity, literature suggests that such a tax has the potential to reduce emissions.

In the third section, the model and data were discussed. This was followed by an analysis of the results. As expected, the electricity generation tax will create distortions in the economy. The real GDP, real private consumption, real public consumption and real investment will decrease. Due to the decrease in domestic demand, export volume is expected to increase and import volume to decrease, despite a weaker terms of trade. These results are in line with the findings of Van Heerden, Blignaut and Jordaan (2008), who found that the direct effects of a 10 percent tax on the price of electricity are mostly negative. This paper allowed unskilled workers to migrate, but assumed a limited skilled workforce, and found that unemployment for unskilled workers is expected to increase and wages of skilled workers are expected to decrease.

It is therefore clear that an electricity generation tax will impose a cost on the South African economy, in terms of a reduction in the Gross Domestic Product of South Africa. However, the electricity generation tax is also expected to yield a positive effect on the South African economy, in terms of the benefits derived from pollution abatement. Ultimately, the government will achieve the objective of the electricity generation tax, namely the reduction of CO_2 emissions, at the expense of a slight reduction in output.

A unilateral electricity generation tax will benefit other SACU and SADC countries through an improvement in relative competitiveness, as shown by the improvement of the terms of trade for these regions.

References

Blignaut, J Chitiga-Mabugu, M R and Mabugu, R M (2005): "Calculating a Greenhouse Gas Emissions Database Using Energy Balances: The Case of South Africa 1998", *Journal of Energy in Southern Africa,* 16(3), 105-116.

Blignaut, J and De Wet, T (2001): "Some Recommendations Toward Reducing Electricity Consumption in the South African Manufacturing Sector", *South African Journal of Economic and Management Sciences*, 4(2), 359–379.

Dimaranan, B V (ed.) (2006): *Global Trade, Assistance, and Protection: The GTAP 6 Data Base,* Centre for Global Trade Analysis, Purdue University.

Eskom Holdings Limited (2009): *Annual Report 2009,* www.eskom.co.za/annreport09.

Hertel, T W (1997): *Global Trade Analysis: Modelling and Applications,* Cambridge University Press. Cambridge.

Hertel, T W and Will, M (2001): "Second-best Considerations in Multilateral Trade Liberalization", *Review of International Economics,* 9(2), 215-232.

Kerkela, L (2004): *Distortion Costs and Effects of Price Liberalisation in Russian Energy Markets: A CGE Analysis,* presented at the 7th Annual Conference on Global Economic Analysis, Washington DC.

McKibbin, W J and Wilcoxen, P J (2002): "The Role of Economics in Climate Change Policy", *Journal of Economic Perspectives,* 16(2), 107–129.

Norregaard, J and Reppelin-Hill, V (2000): "*Taxes and Tradable Permits as Instruments for Controlling Pollution: Theory and Practice",* IMF Working Paper. WP/00/13.

Organisation for Economic Co-operation and Development (2001): *Environmentally Related Taxes in OECD: Issues and Strategies*, Paris, OECD.

Perkins, D H Radelet, S and Lindauer, D L (2006): *Economics of Development, Sixth Edition,* Norton & Company Inc.

Republic of South Africa (2008): *Budget Review – 2008,* National Treasury, Pretoria.

Republic of South Africa (2007): *Energy Security Master Plan – Electricity, 2007 – 2025,* Department of Minerals and Energy, Pretoria.

Republic of South Africa (2007): *Long Term Mitigation Scenarios: Technical Summary,* Scenario Building Team (SBT), Department of Environment Affairs and Tourism, Pretoria.

Republic of South Africa (2006): *Digest of South African Energy Statistics,* Directorate: Energy Planning and Development, Department of Minerals and Energy, Pretoria.

Republic of South Africa (2006): *Draft Policy Paper: A Framework for Considering Market-Based Instruments to Support Environmental Fiscal Reform in South Africa,* Unpublished Draft Policy Paper for the National Treasury, Pretoria.

Republic of South Africa (2009): *Electricity Generated and Available for Distribution (200811),* Statistics South Africa. www.statssa.gov.za.

Rosen, H S (1999): *Public Finance, 5th ed,* Columbus, OH McGraw-Hill.

Rutherford, T F and Paltsev S V (2000): “GTAPinGAMS and GTAP-EG: Global Datasets for Economic Research and Illustrative models”, *Working Paper,* Department of Economics, University of Colorado.

University of Pretoria. (2007): “An Electricity-Based Environmental Tax for South Africa”, *Unpublished research report for the National Treasury*, Department of Economics and Institute for Environmental Studies, VU University (UP), South Africa.

Van Heerden, J H Blignaut, J and Jordaan, A (2008): “Who Would Really Pay for Increased Electricity Prices in South Africa?”, *13th Annual Conference on Econometric Modelling in Africa,* University of Pretoria, South Africa.

Van Heerden, J H Blignaut, J Gerlagh, R Hess, S Horridge, M Mabugu, M R and Mabugu, R M (2006): “Searching for Triple Dividends in South Africa: Fighting CO_2 Pollution and Poverty While Promoting Growth”, *The Energy Journal*, 27(2), 113–141.

Winkler, H (ed.) (2007): *Long Term Mitigation Scenarios: Technical Report,* The Energy Research Centre, for Department of Environment Affairs and Tourism, Pretoria.

APPENDIX

Table A1: Sectoral composition of GTAP

Identifier	Sectors in Region
Electricity	Electricity
Grains and crops	Paddy rice
	Wheat
	Cereal grains nec
	Vegetables, fruit, nuts
	Oil seeds
	Sugar cane, sugar beet
	Processed rice
Livestock and meat products	Cattle, sheep, goats, horses
	Animal products nec
	Raw milk
	Wool, silk-worm cocoons
	Meat: cattle, sheep, goats, horse
	Meat products nec
Mining and extraction	Forestry and fishing
	Coal
	Oil and gas
	Mineral nc
Processed food	Vegetable oils and fats
	Dairy products
	Sugar
	Food products nec
	Beverages and tobacco products
Textiles and clothing	Textiles
	Wearing apparel
Light manufacturing	Leather products
	Wood products
	Paper products, publishing
	Metal products
	Motor vehicles and parts
	Transport equipment nec
	Manufactures nec
Heavy manufacturing	Petroleum, coal products
	Chemical, rubber, plasticprods
	Mineral products nec
	Ferrous metals
	Metals nec
	Electronic equipment
	Machinery and equipment nec
Utilities and construction	Gas manufacture, distribution
	Water
	Construction
Transport and communication	Trade
	Transport nec
	Sea transport
	Air transport
	Communication
Other services	Financial services nec
	Insurance
	Business services nec
	Recreation and other services
	Public Admin, defence, health, education
	Dwellings